

**What is claimed is:**

1. A method of manufacturing a rigid foam comprising:
  - preparing a polymer melt;
  - incorporating nano-particles into the polymer melt;
  - incorporating a blowing agent into the polymer melt under a first pressure and at a first temperature;
  - extruding the polymer melt under a second pressure and at a second temperature, the second pressure and second temperature being sufficient to allow the polymer melt to expand and form a foam; and
  - cooling the foam to form a foam product having an average cell size, a cell size distribution, an average cell wall thickness, an average cell strut diameter, a cell orientation, a thermal conductivity, a foam density and a foam strength.
  
2. A method of manufacturing a rigid foam according to claim 1, wherein:  
the polymer includes a major portion of at least one alkenyl aromatic polymer selected from a group consisting of alkenyl aromatic homopolymers, copolymers of alkenyl aromatic compounds and copolymerizable ethylenically unsaturated co-monomers.

3. A method of manufacturing a rigid foam according to claim 2, wherein:
  - the polymer includes a major portion of at least one alkenyl aromatic polymer selected from a group consisting of the polymerization products of styrene,  $\alpha$ -methylstyrene, chlorostyrene, bromostyrene, ethylstyrene, vinyl benzene, and vinyl toluene; and
    - a minor portions of a non-alkenyl aromatic polymer.
4. A method of manufacturing a rigid foam according to claim 3, wherein:
  - the polymer includes at least 80 wt% polystyrene.
5. A method of manufacturing a rigid foam according to claim 2, wherein:
  - the blowing agent includes at least one composition selected from a group consisting of aliphatic hydrocarbons having 1-9 carbon atoms, halogenated aliphatic hydrocarbons having 1-4 carbon atoms, carbon dioxide, nitrogen, water, azodicarbonamide and p-toluenesulfonyl.
6. A method of manufacturing a rigid foam according to claim 5, wherein:
  - the blowing agent includes at least one composition selected from a group consisting of methane, methanol, ethane, ethanol, propane, propanol, n-butane and isopentane, carbon dioxide, nitrogen, water, azodicarbonamide, p-toluenesulfonyl, HCFC-142b and HCFC-134a.

7. A method of manufacturing a rigid foam according to claim 2, further comprising:  
incorporating an additive into the polymer melt before forming the foam.
8. A method of manufacturing a rigid foam according to claim 7, wherein:  
the additive includes at least one composition selected from a group consisting of  
flame retardants, mold release agents, pigments and fillers.
9. A method of manufacturing a rigid foam according to claim 2, wherein:  
the nano-particles have a minimum dimension of less than about 100 nm and are  
selected from a group consisting of calcium carbonate, intercalated clays, intercalated  
graphites, exfoliated clays and expanded graphites.
10. A method of manufacturing a rigid foam according to claim 9, wherein:  
the nano-particles are incorporated into the polymer melt at a rate of between 0.01  
and 10 weight percent, based on polymer weight.
11. A method of manufacturing a rigid foam according to claim 9, wherein:  
the nano-particles are incorporated into the polymer melt at a rate of between 0.5  
and 5 weight percent, based on polymer weight.

12. A method of manufacturing a rigid foam according to claim 11, wherein:
  - the nano-particles include a major portion of nano-Montmorillonite (MMT); and
  - the polymer includes a major portion of polystyrene (PS), polyethylene (PE) or polymethyl methacrylate (PMMA).
13. A method of manufacturing a rigid foam according to claim 10, wherein:
  - the nano-particles are formed by a technique selected from a group consisting of intercalation with polystyrene, in-situ polymerization of polystyrene (PS) or polymethyl methacrylate (PMMA) with a surface modified nano-Montmorillonite (MMT), and
  - exfoliation of expandable graphite particles in a polystyrene or polymethyl methacrylate matrix.
14. A method of manufacturing a rigid foam according to claim 2, wherein:
  - the average cell size is less than about 500  $\mu\text{m}$ ;
  - the average cell wall thickness is less than about 10  $\mu\text{m}$ ;
  - the average strut diameter is less than about 20  $\mu\text{m}$ ;
  - the cell orientation is between about 0.5 and 2.0; and
  - the foam density is less than about 100  $\text{kg/m}^3$ .

15. A method of manufacturing a rigid foam according to claim 14, wherein:
  - the average cell size is between about 60 and about 120  $\mu\text{m}$ ;
  - the average cell wall thickness is between about 0.2 and about 1.0  $\mu\text{m}$ ;
  - the average strut diameter is between about 4 and about 8  $\mu\text{m}$ ;
  - the cell orientation is between about 1.0 and about 1.5; and
  - the foam density is between about 20 and about 50  $\text{kg/m}^3$ .
16. A method of manufacturing a rigid foam according to claim 2, further comprising:
  - incorporating a conventional nucleation agent into the polymer melt at a rate of less than about 2 weight percent based on polymer weight.
17. A method of manufacturing a rigid foam according to claim 16, wherein:
  - the cell size distribution is bimodal, with a first peak centered between about 50  $\mu\text{m}$  and 120  $\mu\text{m}$  and a second peak centered above 200  $\mu\text{m}$ .

18. A rigid foam comprising:

at least about 80 weight percent of a polymer matrix including a major portion of at least one alkenyl aromatic polymer selected from a group consisting of alkenyl aromatic homopolymers, copolymers of alkenyl aromatic compounds and copolymerizable ethylenically unsaturated co-monomers; and less than about 10 weight percent nano-particles having a minimum dimension of less than about 100 nm;

the polymer matrix being further characterized by

an average cell size of between about 60 and about 120  $\mu\text{m}$ ;  
an average cell wall thickness of between about 0.2 and about 1.0  $\mu\text{m}$ ;  
an average strut diameter of between about 4 and about 8  $\mu\text{m}$ ;  
a cell orientation is between about 1.0 and about 1.5; and  
a foam density of between about 20 and about 50  $\text{kg/m}^3$ .

19. A rigid foam according to claim 18, wherein:

the polymer matrix is further characterized by  
a foam compressive strength of at least 300 kPa according to ASTM D1621.

20. A rigid polymer foam according to claim 18, wherein:

the cell orientation is at least 1.2; and  
further wherein at least 90 % of the cells are closed cells.